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1. Your reference 2DGRAT 1

2. Patent *(The Pa* 9921445.4 -8 SEP 1999

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

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If the applicant is a corporate body, give the country/state of its incorporation

UK 79818001

4. Title of the invention

2D Lattice Distributed Reflectors Light Emitters.

5. Name of your agent *(if you have one)*

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
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9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	0
Description	2
Claim *(s)*	2
Abstract	1
Drawing *(s)*	3 only

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Priority documents	
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
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11. I/We request the grant of a patent on the basis of this application.

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DUPLICATE

Background to the Invention

There is considerable interest currently in simple and low cost techniques for achieving robust yet simple laser sources with high quality spectral performance for low cost data-communication applications. Conventional DFB and DBR lasers require expensive regrowth techniques. Work on deep etched DBRs has been carried out with encouraging results, but single mode operation was not obtained [1]. In this paper, we report for the first time the introduction of a 2D-lattice distributed reflector into a simple ridge laser cavity leading to high quality mode-hop-free single-line lasing action. To highlight the effectiveness of the grating and the potential for laser construction in a manner not requiring regrowth, the photonic grating structure is introduced into a standard Fabry Perot diode laser by post-processing using Focused Ion Beam Etching. This allows a single-contact, mode-hop-free, single longitudinal mode laser operating CW at room temperature to be produced from a previously multi-mode Fabry-Perot ridge-waveguide device.

A specific embodiment of the invention is now described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 illustrates a top-down photograph of the present invention showing the central etched region (dark grey) towards the left hand side of the image. (The large circular artefact in the lower part of the image is the bond wire contact.)

Figure 2 illustrates a schematic of the present invention showing the etch carried out.

Figure 3 illustrates the room temperature (20°C) CW optical spectra at 60mA for (a) pre-etch non-AR coated and (b) post-etch AR coated conditions of the present invention

Figure 4 illustrates the post-etch room temperature (20°C) CW L-I characteristics of present invention.

Figure 5 illustrates the post-etch, room temperature (20°C) variation of lasing wavelength with CW bias current for the present invention.

Device Structure

The device under consideration is an InGaAsP-InP ridge-waveguide laser, consisting of seven 0.8% compressively strained quantum wells, which operates at a centre wavelength of ~1.29μm. The 350μm long Fabry-Perot (F-P) laser is cleaved on both facets. The laser is bonded junction side up on a temperature-controlled submount, and the output is monitored via a lensed fibre. Prior to the etching of the 2D-lattice grating, the back facet is AR coated to 0.1%, in order to suppress the F-P modes. Using focused ion beam etching, a 2D hexagonal array of holes is etched through the top contact over a 50μm length region, positioned towards the back facet, as shown in figures 1 and 2. The holes are etched on either side the central ridge to a depth comparable to that of the active region, with a pitch of 1.3μm and a radius-to-pitch ratio of 0.17 [2].

Device Performance

The post-etch performance of the device is characterised in terms of the optical spectra. Measurements are taken at room temperature (20°C) under CW bias conditions. Figure 3a shows the pre-etch spectrum before AR coating at 60mA. This is indicative of a typical multi longitudinal mode F-P structure. Figure 3b illustrates clearly that after etching, the device lases in a single longitudinal mode. Purely single mode operation is maintained over the entire operating current range up to over 3 times threshold. A typical SMSR value of >30dB is measured, with a maximum value of 38dB.

In order to investigate the stability of the lasing wavelength, the light current characteristics under CW bias conditions are measured at room temperature. Figure 4 shows a linear response above threshold, with no kinks evident, indicating that mode-hopping does not occur. A slope efficiency of $0.09WA^{-1}$ is measured along with an output power of greater than 2.5mW at twice threshold current. At room temperature, a reduction in threshold current of 2mAwas observed as a result of the etch.

Single mode operation is further evidenced in figure 5, which shows the variation of peak wavelength with CW bias current at room temperature (20°C). From threshold up to 85mA, the lasing wavelength is found to vary linearly at 0.009nm/mA, indicating mode-hop-free operation. The device spectra remain single mode over this range. Single mode emission is found to vary at the rate of 0.08nm/°C around room temperature.

Summary of the Present Invention

For the first time, we have shown that the introduction of a short etched region, consisting of a 2D periodic array of holes, around the ridge-waveguide of a F-P laser can be used to create a single-contact, mode-hop-free, single longitudinal mode laser operating CW at room temperature. This simple post-processing technique using focused ion beam etching could easily be implemented using RIE during fabrication, and therefore would provide a low cost alternative to conventional DBR devices which require expensive regrowth techniques. Further results concerning the temperature and dynamic performance of the device will be reported at the conference.

References

[1] "1.5μm wavelength DBR lasers consisting of 3λ/4-semiconductor and 3λ/4-groove buried with benzocyclobutene", M.M.Raj, J. Wiedmann, Y. Saka, H. Yasumoto and S. Arai. *Electronics Letter, Vol. 35, No. 16, pp. 1335-1337.*

[2] "Localization of light in disordered and periodic dielectrics", J Sajeev. *Lectures given at Erice Summer School July 1993.*

Claims

1. An edge emitting optical component, based on edge emitting laser diode structures, in which, single wavelength operation is achieved by design of a 2D-lattice distributed reflector so that efficient optical emission (by lasing and/or spontaneous emission) is achieved depending on the electrical bias or biases applied to the device.
2. An optoelectronic component, as defined in claim 1, wherein the modification of the structure may be achieved in manufacture through masking, e-beam lithography, X-ray or reactive ion etching (RIE) or other techniques or may be achieved through a post processing etching (such as focused ion beam etching (FIBE)) or oxidation step or other process.
3. An optoelectronic component, as defined in claim 1, wherein the structure may be an edge emitting Fabry-Perot lasing/amplifying/switching structure based on semiconductor/polymer technologies.
4. An optoelectronic component, as claimed in claim 1, wherein the lattice may be allowed to vary, both in terms of pattern, packing, overall shape and position.
5. An optoelectronic component, as claimed in claim 1, wherein the grating comprises holes that may be allowed to be vertical or at an angle and vary in size, spacing or shape.
6. An optoelectronic component, as claimed in claim 1, wherein the holes are defined as regions of different refractive index to that of the component structure.
7. An optoelectronic component, as claimed in claim 1, wherein the holes are defined as regions of different gain or loss to that of the component structure.
8. An optoelectronic component, as claimed in claim 1, wherein the holes are defined as regions of different refractive index and gain or loss to the component structure.
9. An optoelectronic component, as claimed in claim 1, wherein the grating may be introduced across the waveguide or waveguides on one or both sides.
10. An optoelectronic component, as claimed in claim 1, wherein the grating does not pierce the active region, partially pierce active region or possibly fully pierces the active region.
11. An optoelectronic component, as claimed in claim 1, wherein distributed gratings may be allowed within devices.
12. An optoelectronic component, as claimed in claim 1, wherein gratings may be allowed in pumped or un-pumped regions.
13. An optoelectronic component, as claimed in claim 11, wherein pumping may be of an electrical or optical nature.
14. An optoelectronic component, as claimed in claim 3, wherein any electrical contacts may be isolated.
15. An optoelectronic component, as claimed in claim 1, wherein the emission wavelength may be controlled/tuned.
16. An optoelectronic component, as claimed in claim 1, wherein the device may be operated at high speed.
17. An optoelectronic component, as claimed in claim 1, which operates mode-hop-free.
18. An optoelectronic component, as claimed in claim 1, which is integrated with separate amplifying, absorbing or passive sections.
19. An optoelectronic component, as claimed in claim 18, where the amplifying or absorbing regions may have the gain/loss modulated.

20. An optoelectronic component, as claimed in claim 1, which may be pulsed by gain switching, Q-switching or mode-locking techniques.

2D-lattice Distributed Reflector Light Emitters

Abstract

This invention concerns a new form of single longitudinal mode laser that has been produced using a 2D-lattice wavelength selective grating. The device exhibits mode-hop-free operation across its entire current operating range. Its structure has the form of a modified edge emitting Fabry-Perot laser diode. It is envisaged that extensions of this device could allow the manufacture of low-cost transceiver modules for use in next generation data-communications.

Figure 1

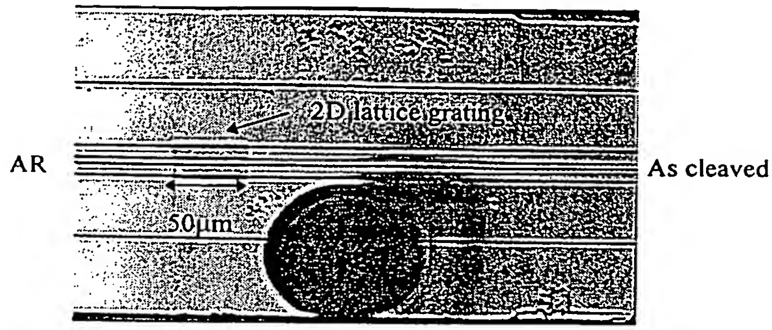


Figure 2

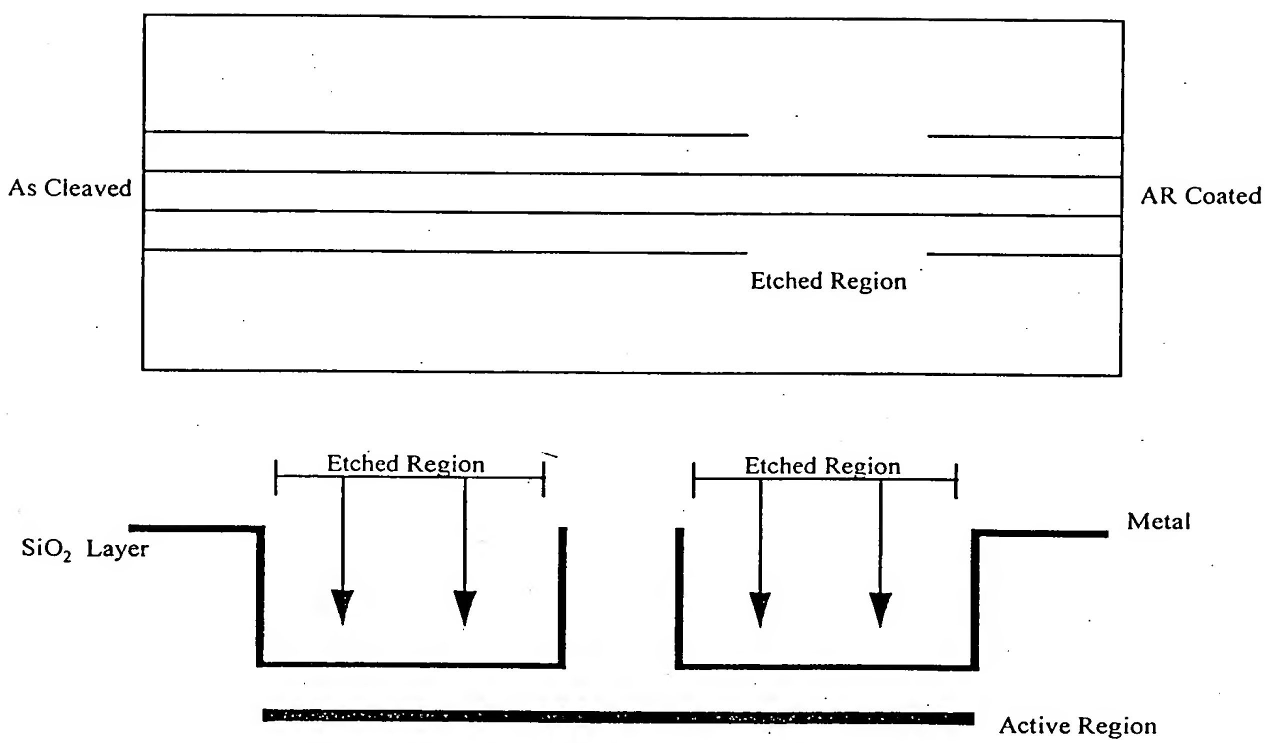
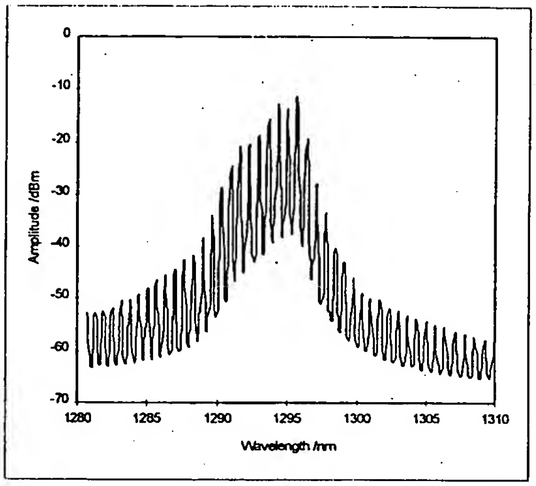
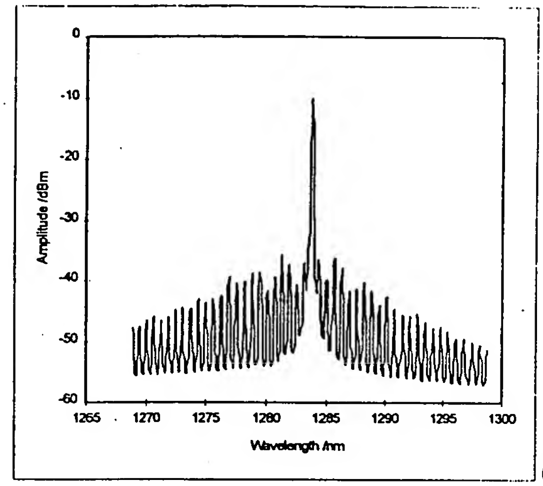


Figure 3



(a)



(b)

Figure 4

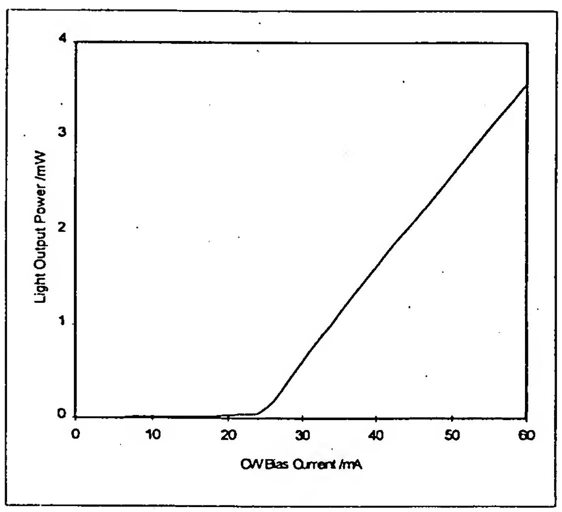
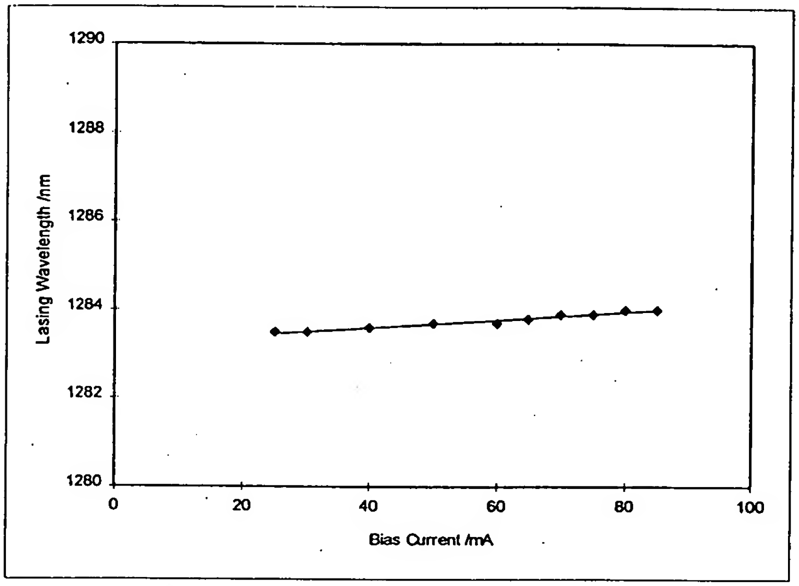


Figure 5



1290
1288
1286
1284
1282
1280
Lasing Wavelength /nm
0
20
40
60
80
100
Bias Current /mA